

4.0 STATEMENT OF WORK

The Pre-Phase A Mission Study at JHU/APL will follow the format provided by GSFC. GSFC and APL will provide a joint Statement of Work at the conclusion of the Pre-Phase A Study.

The primary results of the JHU/APL Study will be a spacecraft definition to support the Instrument Announcement of Opportunity and a significantly higher fidelity cost estimate for Phases A through D.

The JHU/APL tasks for this study are in the following six categories:

- A. Project Management
- B. Mission Design
- C. Instrument Interfaces
- D. Spacecraft Conceptual Design
- E. Mission Integration
- F. Mission Operations

A. Project Management

A more detailed schedule and cost than implied by the use of the words “top level” will be provided for both the 2002 and 2004 opportunities. The breakdown will be provided by fiscal quarters and will be itemized by spacecraft, mission integration, and mission operations.

In the spacecraft category each subsystem will have five to ten line items for both schedule and cost. For mission integration a test flow will provide the details for both schedule and cost. Mission operations, as discussed in a later section, will include both pre-launch and post-launch efforts.

B. Mission Design

The following items will be included in the Pre-Phase A study:

1. Review the single versus dual launch approaches and include STS as a candidate launch approach.
2. Examine the constraints on launch window and how they would be impacted by the launch techniques in B, above.

3. Analyze the spacecraft-sun and spacecraft-earth distances throughout the mission and their impact on mission parameters.

4. Investigate the launch parameters that affect spacecraft design (i.e., eclipse time, ground track).

5. Investigate the implementation method of determining spacecraft position via one-way navigation using an on-board ultra-stable oscillator. Complete a preliminary estimate on position accuracy and detail any requirement that this method places on DSN facilities or DSN antenna time.

6. A launch approach and a launch vehicle will be recommended and a preliminary launch vehicle ICD will be developed.

7. Working with DSN personnel, a Project Service Level Agreement will be completed to enter the STEREO program into DSN planning.

C. Instrument Interfaces

The Announcement of Opportunity for the instruments needs to be out during the last quarter of calendar 1998 in order to support the earlier 2002 launch date. The preliminary spacecraft interfaces with the instruments will be derived during this study. These interfaces include: volume, mass, power, data rate, electrical interface, field of view, temperature, attitude knowledge, and attitude control.

A preliminary instrument Interface Control Document (ICD) will be included in the study. This document will include all spacecraft provided instrument accommodations, including electrical, mechanical, and thermal. It will also include instrument operability issues such as instrument-command storage and data-storage limitations.

Because jitter is a major issue for the coronagraph, trade studies will be performed, but not included in the ICD, on the allocation of jitter between the instruments and the spacecraft.

D. Spacecraft Conceptual Design

The following items will be included in the Pre-Phase A study:

1. Identify, using previous analyses by GSFC, and further work via this study the Level 1-mission requirements. Focus on those

requirements which appear to be the more significant cost drivers and examine alternative, if any, less costly solutions. An effort will be made to partition these requirements between the flight system and the ground system. For example, a significant trade study will detail the expense of the ground antenna time (DSN) versus the size of telecommunication system on the spacecraft.

A one-day Requirements Review will be held to review the Level-1 Requirements. A top-level spacecraft descope plan will be delivered that addresses both schedule and cost risks as a function of project phase.

2. Prepare the system block diagram; identify any redundancy and rationale. To maintain a high confidence in the STEREO cost estimate, the system architecture will be based on a single-string derivative of the redundant TIMED design with selective redundancy added. The choice of where to add redundancy is a function of the increase in system reliability and cost and the impact of any modifications to the baseline TIMED design.

A system-level cost/benefit analysis of adding selective redundancy to various spacecraft components will be delivered.

3. Identify spares philosophy. A qualitative approach to spares will be presented, i.e., kits, board level, units, etc.

4. Identify configuration management level. Typical configuration management plans for JHU/APL will be provided.

A preliminary Procurement Product Assurance Requirements Document and a preliminary Component Environmental Specification will be generated. The first document lists the part-level requirements and configuration management requirements for the project, including latchup immunity and latchup protection. It should be noted that APL's product-assurance approach to purchased items is to use the subcontractor's documentation methods and procedures when they meet the minimum acceptable standards. The Component Environmental Specification details the thermal, vibration, shock, and acoustic tests that components must pass prior delivery for spacecraft integration, and lists the level and duration of the various tests that they will experience at the system level.

A preliminary Software Development Plan will be delivered.

5. Perform subsystem conceptual designs. Lead engineers in each subsystem will detail subsystem-level requirements and define their design solution. Preliminary component level make-or-buy decision will be made, and subsystem performance estimates given.

Both hardware and software heritage down to the component level will be included. For the software element, a software build plan and schedule will be developed that will detail what software functions are to be included in each software release.

A preliminary dynamic-spacecraft model will be constructed to estimate spacecraft pointing control performance.

6. Prepare mass/power lists at the component level. These lists will also note the heritage of each component. All margins will be held at the system level, with no reserve allocated to subsystems. The goal is to maintain a 20-25% margin in power and mass at the conclusion of the study.

7. Provide a preliminary overall mechanical layout using instrument interface requirements from Science Definition Study Report.

The mechanical layout shall be of sufficient detail to perform a preliminary loads analysis in the next program phase. The layout shall be made available in either a ProE or IDEAS readable format.

8. Provide an estimate of the required DSN support and associated data volume per track over the mission duration. Because DSN X-band 34-meter HEF coverage is widely contested, the spacecraft will be designed to limit 34-meter HEF antenna time in preference to 34-meter BWG antenna support. The required DSN coverage during the first several months of the mission is likely to be a function of the spacecraft's distance from Earth, since the volume of data returned will be limited not by DSN coverage, but by on-board recorder capacity.

The details and definition of broadcast mode will be explored. This will include participation in discussions with GSFC, NOAA, and AF customers of the implementation of receiving the data as well as preliminary design studies for ground systems requirements and spacecraft impacts of implementing the mode.

9. Review the radiation requirement on components within the spacecraft (also on instruments). A worst-case radiation total dose versus shielding material and material thickness will be provided to the lead engineers to aid in parts selection. Latch-up immunity or latch-up protection will be required. (GSFC study will be used as baseline.)

10. A top-level conceptual design and cost estimate will be provided for an APL-designed multi-instrument data processing unit (DPU). This unit could potentially reduce program costs by combining the processing requirements of several low-bandwidth instruments into a single design. The potential instruments that could benefit from this combined DPU are the magnetometer, radio burst tracker, solar wind plasma analyzer, and the energetic particle detector.

11. Identify potential new technology insertion areas and their impact on mission design and/or operations.

12. Provide list of margins on key spacecraft characteristics (pointing, link margin, mass, consumables, etc.). Margin definition shall include a preliminary margin budget broken down per subsystem.

13. A preliminary fault-protection architecture will be described. The various fault-protection modes will be listed and the faults that demote the system into those modes will be detailed.

14. Trade studies will be conducted on adding on-board autonomy to lower mission operations costs. Spacecraft-operability issues to be studied include advanced recorder management features, use of a high-level command language, advanced on-board telemetry processing, autonomous navigation, and autonomous momentum management.

E. Mission Integration

The Integration and Test (I&T) phase will be conducted at JHU/APL. It is assumed that all spacecraft subsystems are fully qualified prior to delivery for this phase (both functionally and environmentally). Likewise, all instruments are to be both functionally and environmentally qualified, as well as fully calibrated prior to delivery for I&T. Details of the I&T phase will be examined during the Pre-Phase A Study. A typical flow for JHU/APL I&T includes serial instrument integration. When fully assembled, this observatory will go through functional testing including electrical compatibility, DSN compatibility, fault protection verification, launch timelines, and operational scenarios. Prior to environmental tests, all deployments will be conducted and a complete functional test will be baselined. Environmental tests will include, but may not be limited to, low frequency sine vibration, thermal cycling and soak, acoustics and mass properties.

Ground support equipment for spacecraft integration and for post-launch operations will be examined during this study. Selection of the GSE architecture

will be based primarily on the challenges associated with integrating and operating two spacecraft.

The instrument GSE and Science Data Center GSE interfaces to the JHU/APL GSE will be examined during this study.

The use of simulators for mission development are generally employed for:

- Instrument/spacecraft compatibility
- Mission ops training
- Post-launch operations:
 - Command verification
 - Spacecraft performance
 - Flight anomalies
 - Software upgrade testing

During this study the need for all of the above facets will be examined.

Institutional requirements for the mission integration program shall be described. A preliminary integration and test plan will be delivered that includes details on the integration and test flow, environmental test plans, and field-site processing. Waterfall and preliminary GANTT (or equivalent) charts will be provided. Special emphasis will be given to the challenges of processing two spacecraft simultaneously.

F. Mission Operations

Recent experience at JHU/APL has shown that using the same personnel and GSE architecture for integration and mission operations is a significant benefit. We anticipate using this approach on STEREO.

Generally, we do not use a significant segment of a Pre-Phase A Study for mission operations. We will, however, provide the schedule and costs requested. During Phase A/B much attention will be concentrated mission operations.

In support of the Pre-Phase A study for STEREO, the GSFC will provide:

- Radiation environment study
- GSFC Grassroots Mission Study
- IMDC study reports (Note: These are on line. We will provide during the study process as needed, not as one big delivery.)
- Manpower support from Instrument Systems Manager, Project Scientist, Mission Manager, and, on an as-needed basis, subsystem engineers.

In addition to schedules and cost information, preliminary mission operations plans and scenarios shall be included. A preliminary Concept of Operations Document will be developed that will include sections on operations management, training, planning, assessment, and command execution. Methods for combining mission operations with TIMED and CONTOUR will be studied. Cost effective methods for operating two similar spacecraft simultaneously will be elaborated.